MEMO Number: UMBC-CMPE450-SRS-Final
DATE: 2023-02-15
TO: E.F.C. LaBerge
FROM: UHDRTZ
SUBJECT: System Requirements Specification

1 INTRODUCTION

1.1 Project Description

The Ultra Hi-Definition Real Time Zoetrope (UHDRTZ) is an interactive art installation based around a disc-shaped artwork that appears to animate when rotated at the correct speed. To achieve this effect, a live video feed of the artwork is rotated digitally, controlled by a hand crank. An overview of the system is shown in Figure 1.1.1.

This project is an improvement to an existing system, originally released as the Real Time Zoetrope (RTZ), followed by two HD revisions HDRTZ and HDRTZ2.

The rotary encoder sends signals to an Arduino Nano BLE (Bluetooth Low Energy). The Arduino is connected via Bluetooth to an Nvidia Jetson TX2 FPGA. The Bluetooth connection is automatic and will pair when both the FPGA and Arduino are powered on.

The FPGA is provided input from two sources and has one output. The FPGA receives location input from the Bluetooth Arduino and visual input from a 4K USB 3.0 Camera. The FPGA outputs the visual data to either a projector or monitor through an HDMI cable as shown in Figure 1.1.2.

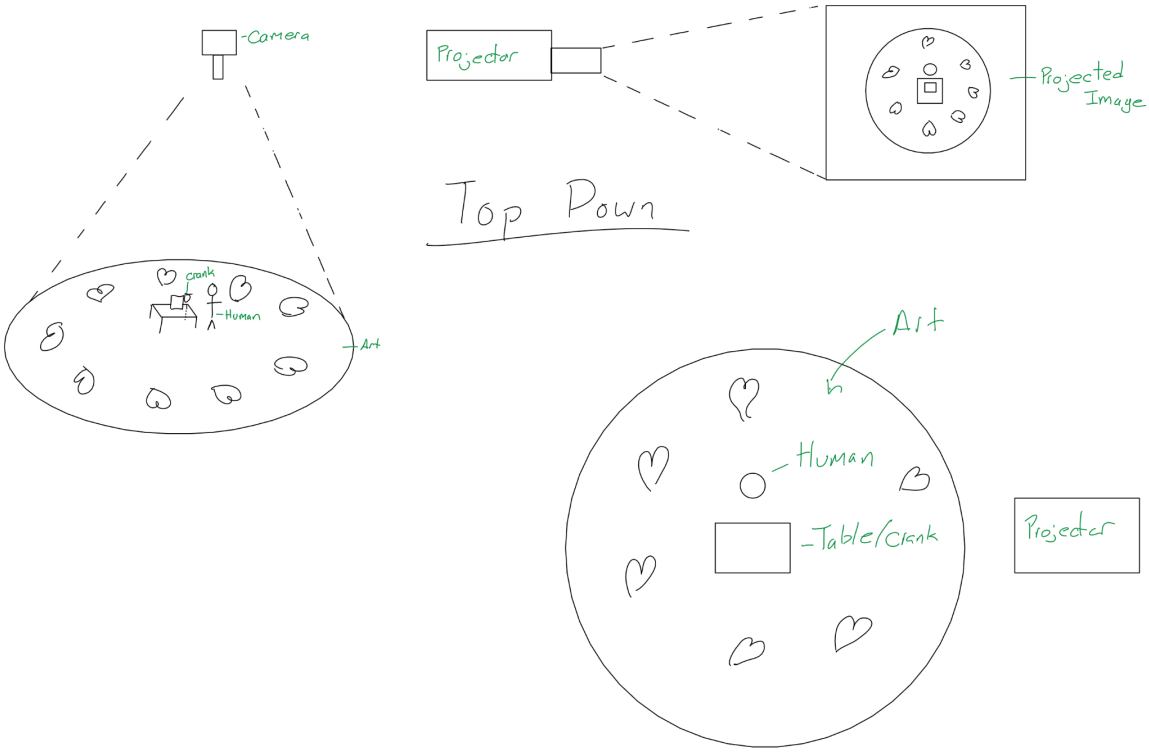

Figure 1.1.1: Mission Scenario Diagram

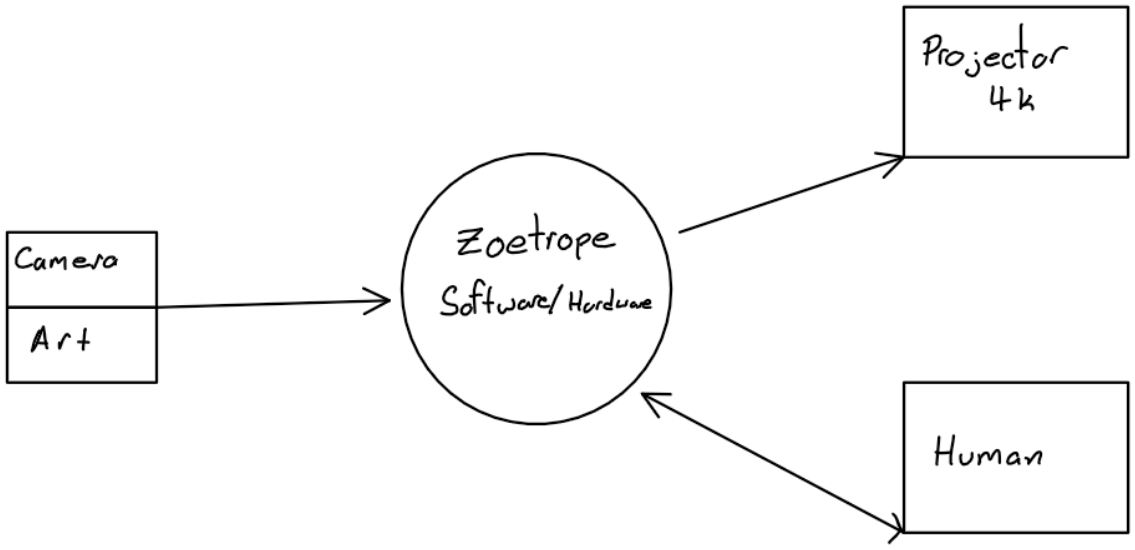

Figure 1.1.2: System Boundary Diagram

1.2 External Standards

1.2.1 USB-2.0 male to USB Micro male connection. IEC 62680 and EC 62680-1
1.2.2 Bluetooth Light Energy. IEEE 802.15.1
1.2.3 AC Power Adapter. IEC 62700
1.2.4 HDMI-2.1 EIA/CEA-861 standard

1.3 Referenced Documents

1.3.1 HDRTZ2 team's code
1.3.2 Demonstration of the system from 2016:
https://userpages.umbc.edu/~dyer/eric-dyer---girona-octopi.html

1.4 Design Considerations

1.4.1 Global Considerations

The HDMI-2.1 standard 48gbps transfer speeds and the 4K camera resolution of 3840x2160 pixels are globally accepted standards.
The device requires a power supply of 120V, 60 cycles. External means of converting power are acceptable.

1.4.2 Environmental Considerations

This section is not applicable.

1.4.3 Economic Considerations

This will not be a mass-produced or replicated product, therefore the economic impact of this project is little to none.

1.4.4 Cultural or Societal Considerations

The UHDRTZ will work with any appropriately designed art installation, therefore this section is not applicable.

1.4.5 Safety Considerations

The arduino circuit within the metal crank housing will be grounded so it does not shock the user.

The FPGA will be safely secured so as to not fall accidentally and cause potential harm to viewers.

1.4.6 Cyber Security Considerations

The device will be password protected as well as being powered off when not in use. The Bluetooth connection will be set to pair only to the Arduino.

1.5 Overview of Document

1.5.1 This document is an overview of the technical requirements and design choices of the UHDRTZ system. This is the introduction to the project and covers all design and testing considerations.

2 SYSTEM REQUIREMENTS

2.1 Functional Requirements

2.1.1 The camera shall capture video in 4K and send that via USB to the FPGA.
2.1.2 The system shall display a rotating image of the artwork.
2.1.3 The interaction with the rotary encoder shall function correctly in both directions.
2.1.4 The crank shall control the speed and direction of rotation.
2.1.5 The system shall provide a digital user interface for maintenance and troubleshooting.
2.1.5.1 The interface shall include settings to enable, disable, move, crop, and resize the image.
2.1.6 The Arduino shall be contained within the crank box
2.1.7 The crank box shall be mountable to a table or podium

2.2 Performance Requirements

2.2.1 The output of the video feed shall be 3840 x 2160 pixels (4K UHD).
2.2.2 The FPGA shall output the video feed at the correct framerate.
Note: The output framerate corresponds to the number of slices in the artwork.
2.2.3 The FPGA shall receive a signal from the Arduino via Bluetooth at a rate of 1 pulse per millisecond.

2.3 Interface Requirements

ID	Source	Destination	Description
2.3.1	Crank	Rotary Encoder	Physical mechanism that the user interacts with to the rotary encoder.
2.3.2	Rotary Encoder	Arduino	Rotating the rotary encoder sends a digital signal to the Arduino.
2.3.3	Arduino	FPGA	Bluetooth connection shall send rotary crank data to the FPGA from the Arduino
2.3.4	Camera	FPGA	The camera shall send visual data of the art to the FPGA

			for processing
2.3.5	FPGA	Projector	FPGA shall provide the spinning image to the projector
2.3.6	AC Power	FPGA	Power shall be provided to FPGA
2.3.7	AC Power	Arduino	Power shall be provided to Arduino

2.3.1 User and Crank to Rotary Encoder

The external crank shaft shall be connected to a rotary encoder and easily accessible for the end user.

2.3.2 Rotary Encoder/Arduino Circuit Connection

The rotary encoder shall be connected to the Arduino through insulated circuit wire.

2.3.3 Arduino

2.3.3.1 The Arduino shall be connected to an AC power cable to ensure constant operation.
2.3.3.2 The Arduino shall be wirelessly connected through Bluetooth to the FPGA.

2.3.4 FPGA

2.3.4.1 Shall receive crank rotational data from the Arduino through Bluetooth.
2.3.4.2 Shall receive visual information from the 4k camera via USB.
2.3.4.3 Shall provide visual output via HDMI to the projector.
2.3.4.4 Video output shall be in 4K.
2.3.4.5 Shall be connected to an AC power cable to ensure constant operation.
2.3.4.6 The software shall produce audio that is clearly audible to the user and other patrons.
2.3.4.7 The audio shall speed up when the crank moves faster.
2.3.4.8 The audio shall play backwards when the user rotates the crank clockwise.

2.4 Testing Requirements

2.4.1 The testing image shall be used to assure the correct setting and controlling of the rotational speed, focus, and color.

2.4.2 The testing audio shall prove that the system can play audio both forwards and backwards in conjunction with the crank moving.

2.4.3 The user interface shall facilitate the changing and modifying of system variables such as, hue, saturation, color, and masks, to meet the required outputs for the use case.

2.5 Design Requirements

2.5.1 The total cost of the project shall not exceed $500.

3 VERIFICATION

The requirements in Section 2 will be verified using a combination of test (T), demo (D), inspection (I), and analysis (A), as described in Table 3.1.

Table 3.1: Verification Matrix

ID	Description	T	D	I	A
2.2.1	Output resolution			x	x
2.2.2	Output frame rate			x	x
2.2.3	Bluetooth tick rate				x
2.3.2	Rotary encoder connected to Arduino	x	x	x	
2.3.3	Bluetooth connection	x			x
2.3.4.2	Camera visual signal	x	x		x
2.3.4.3	Spinning image generation	x	x	x	
2.3.4.5	FPGA power	x		x	
2.3.3.1	Arduino power	x		x	